



Armed Forces College of Medicine

AFCM



Cardiac reserve, cardiac work and O₂ consumption

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INTENDED LEARNING OBJECTIVES (ILO)



By the end of this lecture the students will be able to:

- 1) Describe cardiac reserve with its parameter's limitations, and mechanisms
- 2) Describe cardiac output curve , hypo-effective and hyper-effective hearts and their causes.
- 3) List the types of work done by the heart
- 4) Describe mechanical efficiency of the heart
- 5) Describe the O_2 consumption by the heart
- 6) Apply the information studied in this section to solve a clinical problem or explain clinical case.

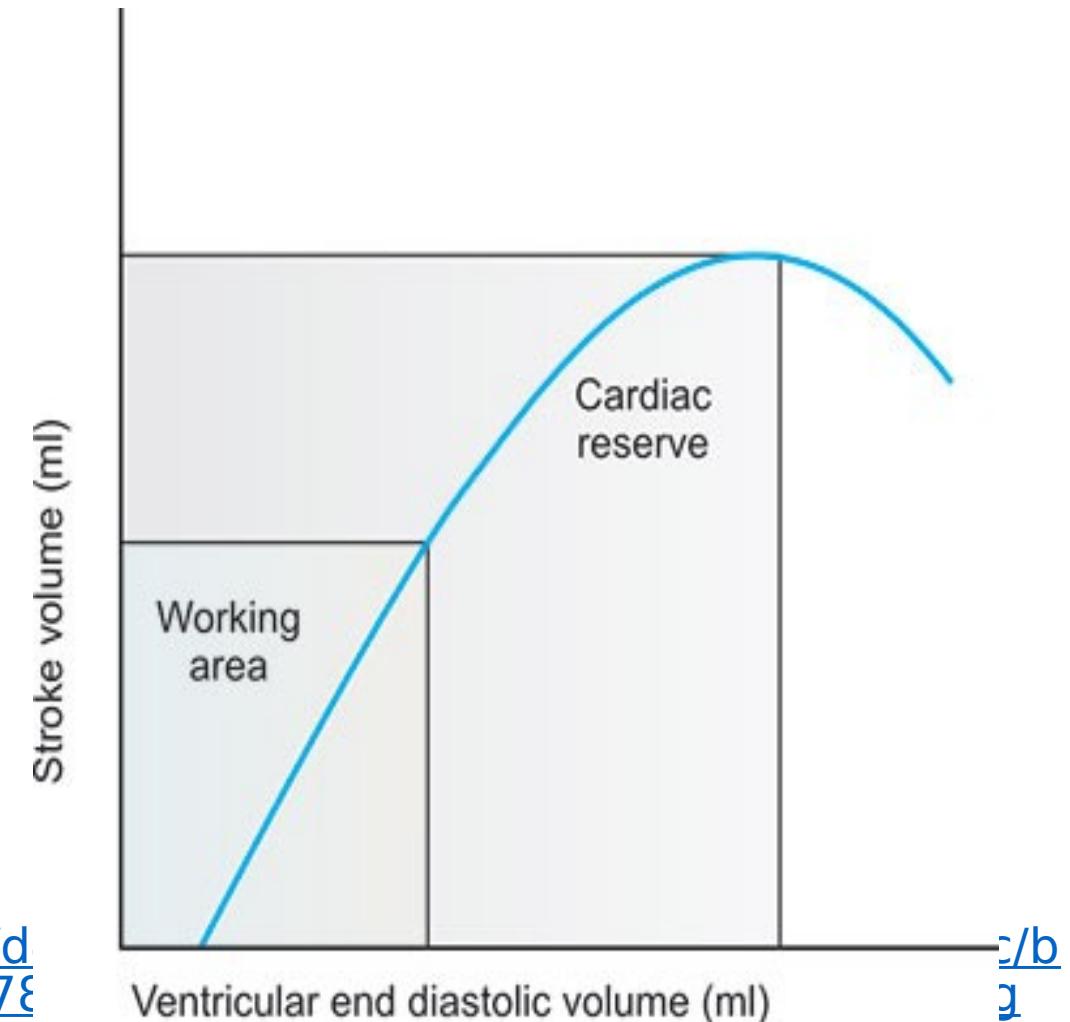
Cardiac Reserve



Definition:

It is the ability of the heart to augment its CO in order to meet the body demands.

- ✓ It equal the difference between basal and maximal cardiac output or work.
- ✓ **Cardiac reserve = Maximal cardiac output - basal cardiac output**



Mechanisms of cardiac reserve



A) Short acting mechanisms:

Moment to moment increase in CO to meet the increased demands.

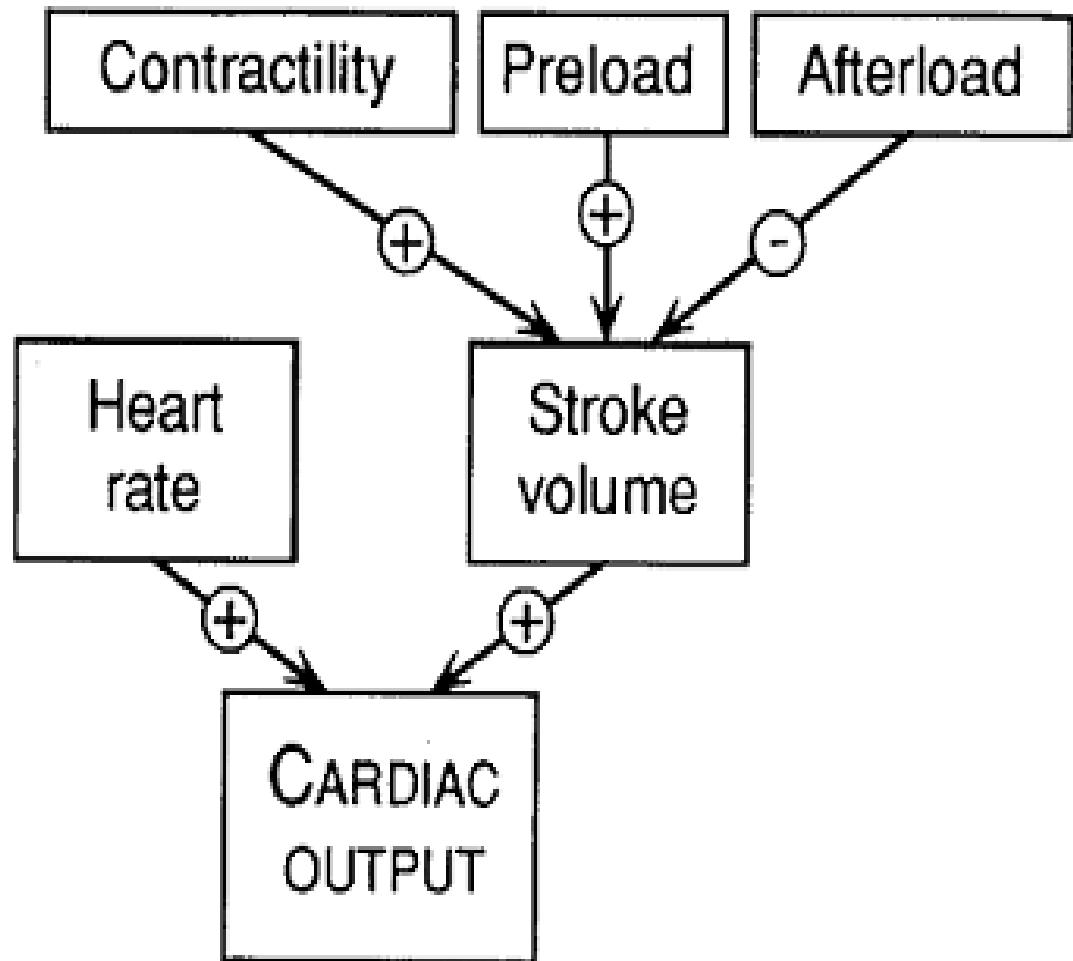
1) Increase CO up to 13 L/min (permissive limit):

a) Heart rate increase:

- Happen by inhibition of vagal tone.....

b) Stroke volume:

Increased by increased venous return (EDV) : heterometric mechanism



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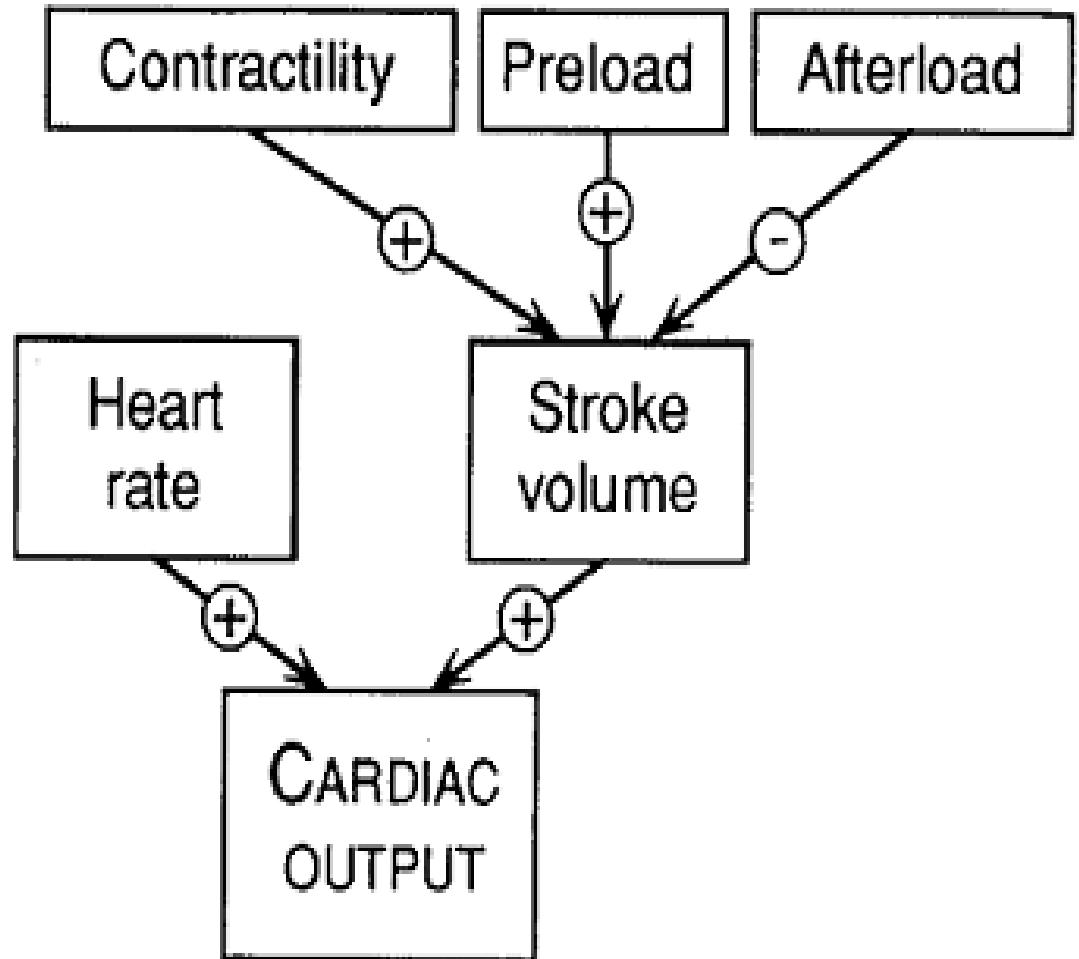
Mechanisms of cardiac reserve



2) Increase CO above the permissive limit:
sympathoadrenal stimulation
due to

a) Heart rate reserve mechanism:
+ve chronotropic up to 180 beat per minute.

b) Stroke volume reserve mechanism:
+ve inotropic effect with constant EDV, SV increase by increasing SV and decreasing



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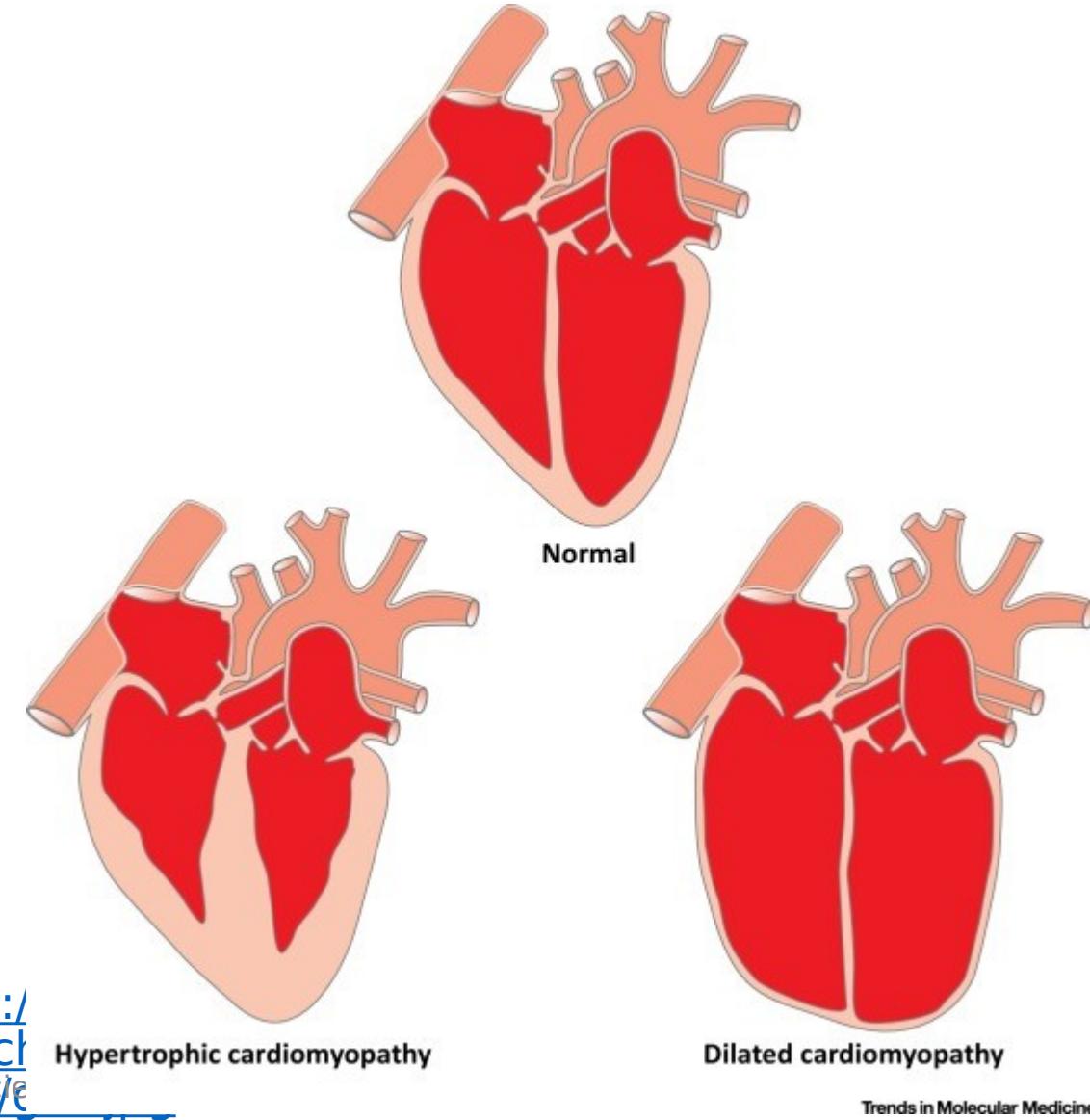
Mechanisms of cardiac reserve



B) Long term Mechanisms :
Slowly and gradual acting mechanism:

1) Dilation :

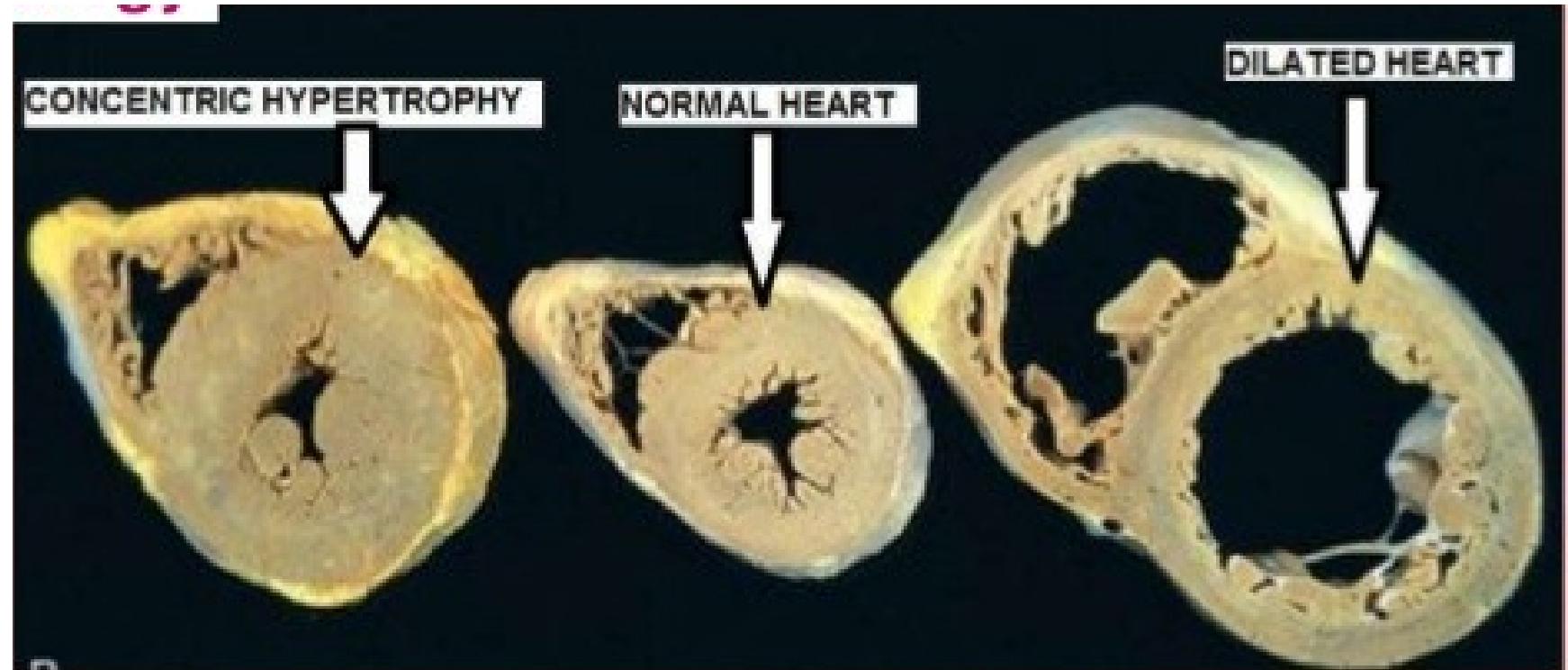
- ✓ Depend on frank starling law increasing EDV.
- ✓ Occur in volume overload as aortic incompetence, ventricular septal defect and congestive heart failure.



2) Hypertrophy:

- ✓ Increased number and thickness of cardiac muscles, increasing <https://attach.a9/e>
- ✓ Occurs in pressure overload again

Mechanisms of cardiac reserve



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Cardiac Reserve Limitation



permissiv
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No
limitation

Contractili
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Hypertrop
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Limitation
s

EDV

Sympathe
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Heart
rate

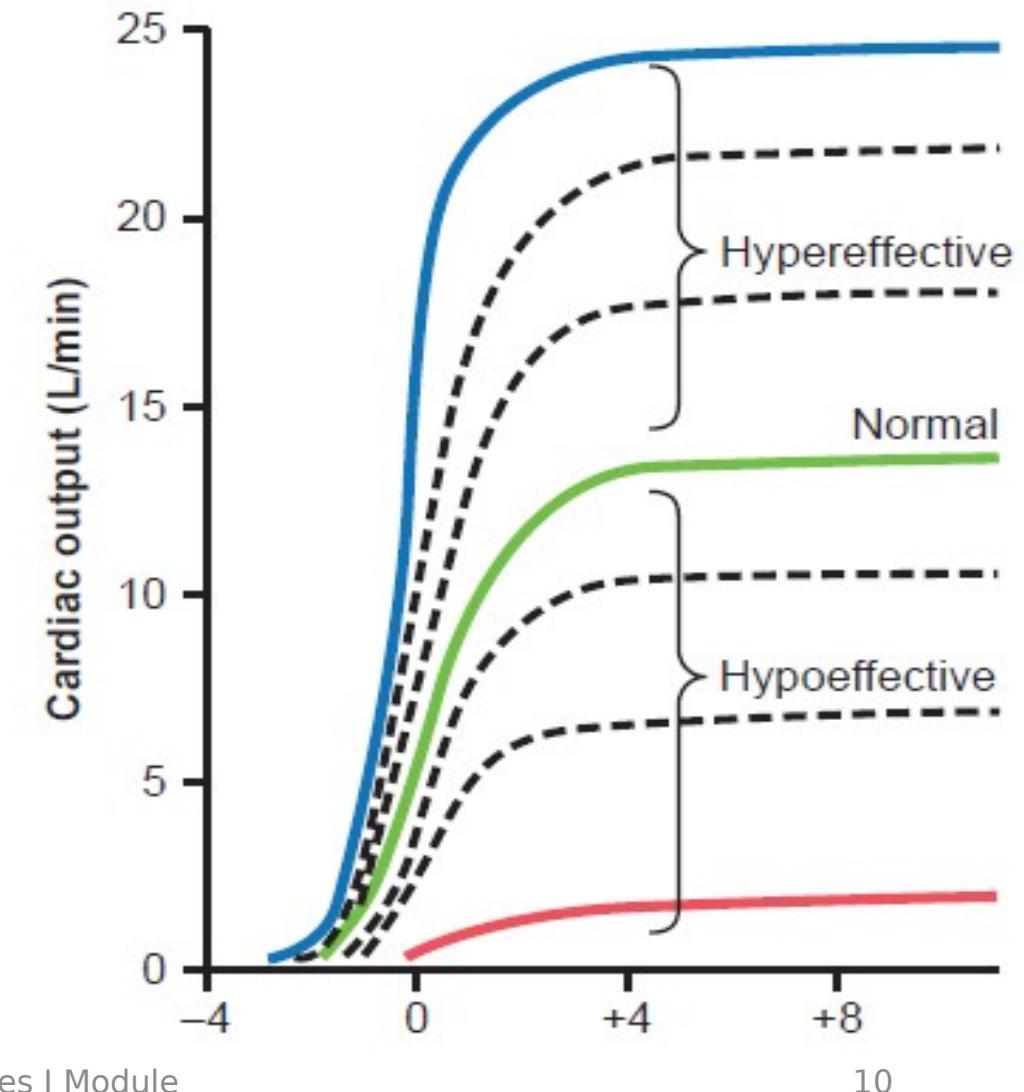


Cardiac Output Curve

✓ Causes of hyper-effective heart:

Hyper-effective heart is heart with increased cardiac output better than normal. It can be caused by:

- 1) New Marathon runners - how Co increase up to 40L/min.
- 2) Left ventricular hypertrophy - how Co increase up to 40L/min ?



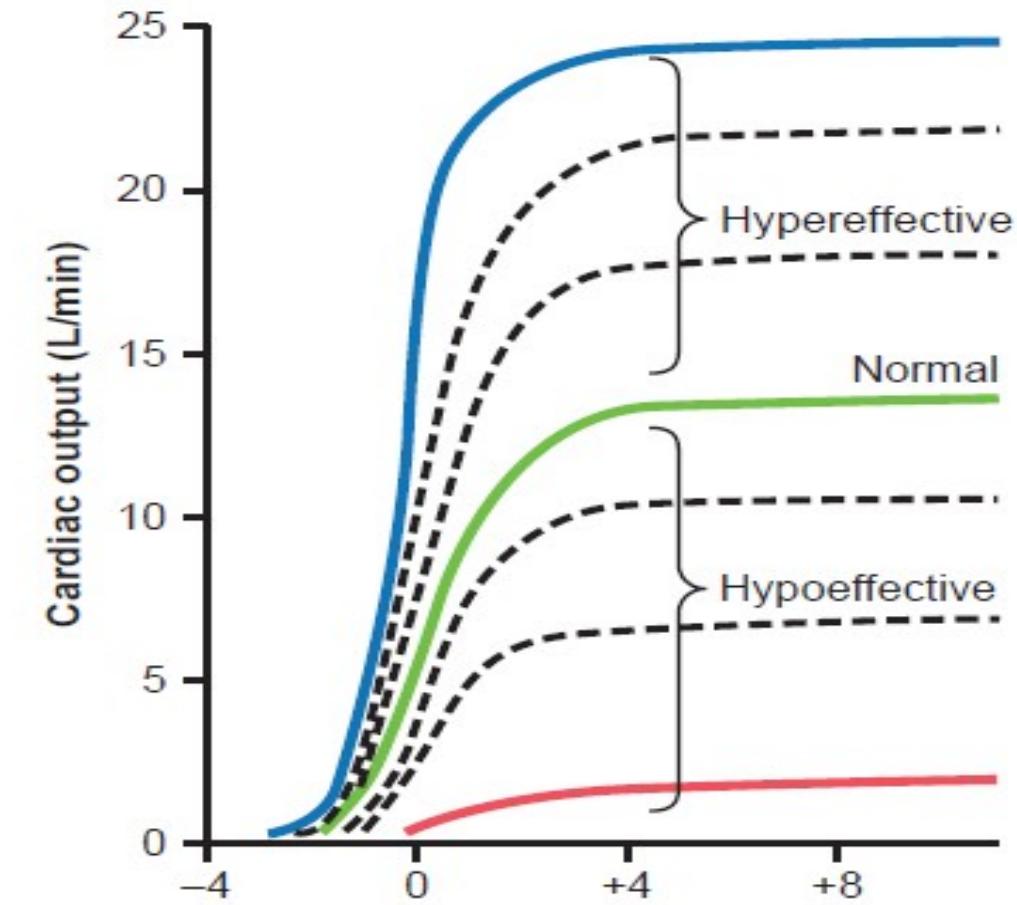
Hyper-effective and Hypo-effective heart



✓ Causes of hypo-effective heart:

Hypo-effective heart is heart with decreased cardiac output. It can be caused by:

- 1) Increased arterial pressure such as in severe hypertension.
- 2) Inhibition of nervous excitation of the heart.
- 3) Arrhythmias.
- 4) Coronary artery insufficiency.
- 5) Valvular heart disease.
- 6) Congenital heart disease.
- 7) Myocarditis.
- 8)



Guyton and Hall 13th edition



Cardiac Work

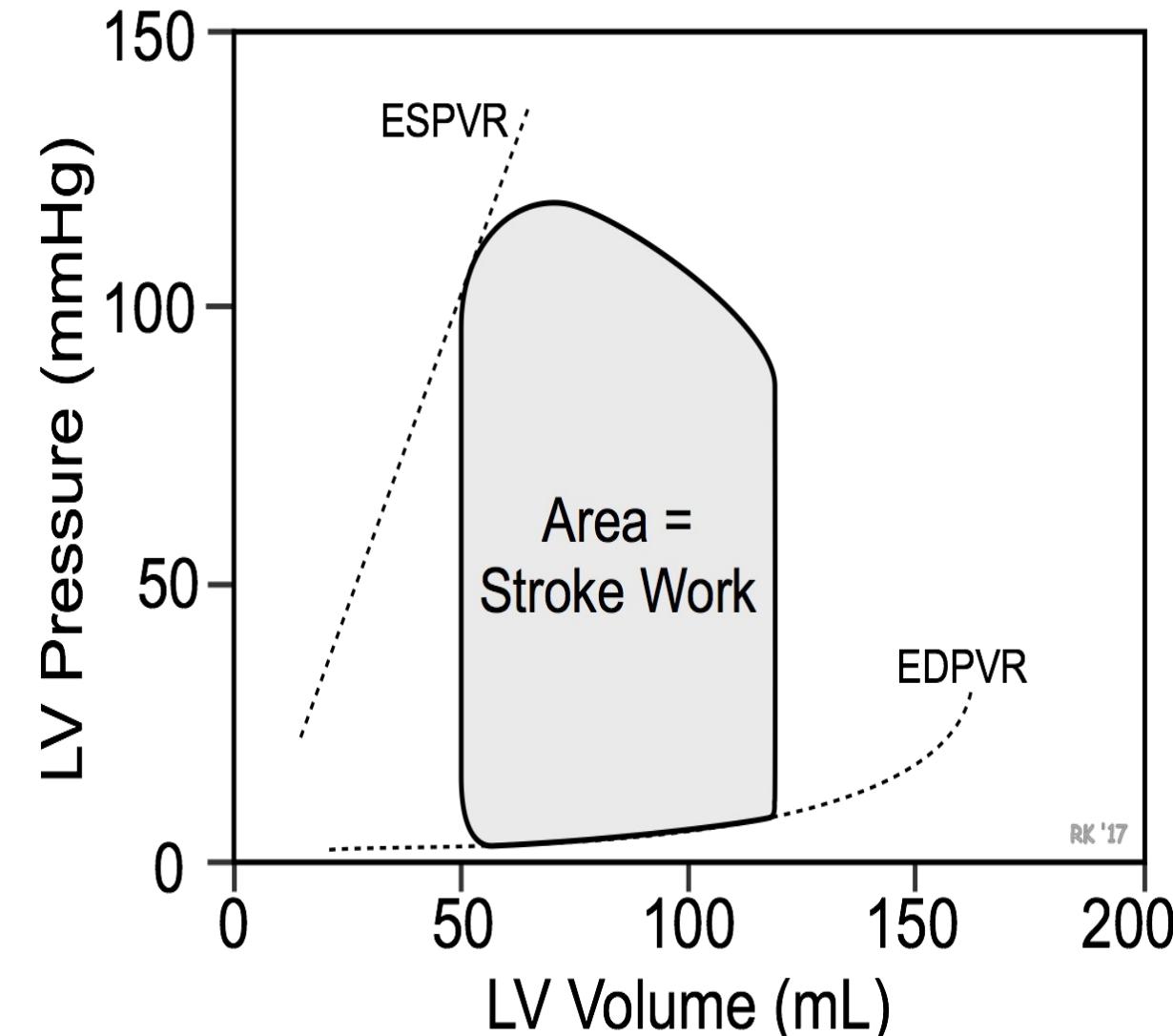
Types of cardiac work:

✓ Stroke Work:

- **Stroke work = stroke volume × mean arterial pressure.**
- **Left ventricle have stroke work 7 times than that of right ventricle WHY?**

✓ Minute work:

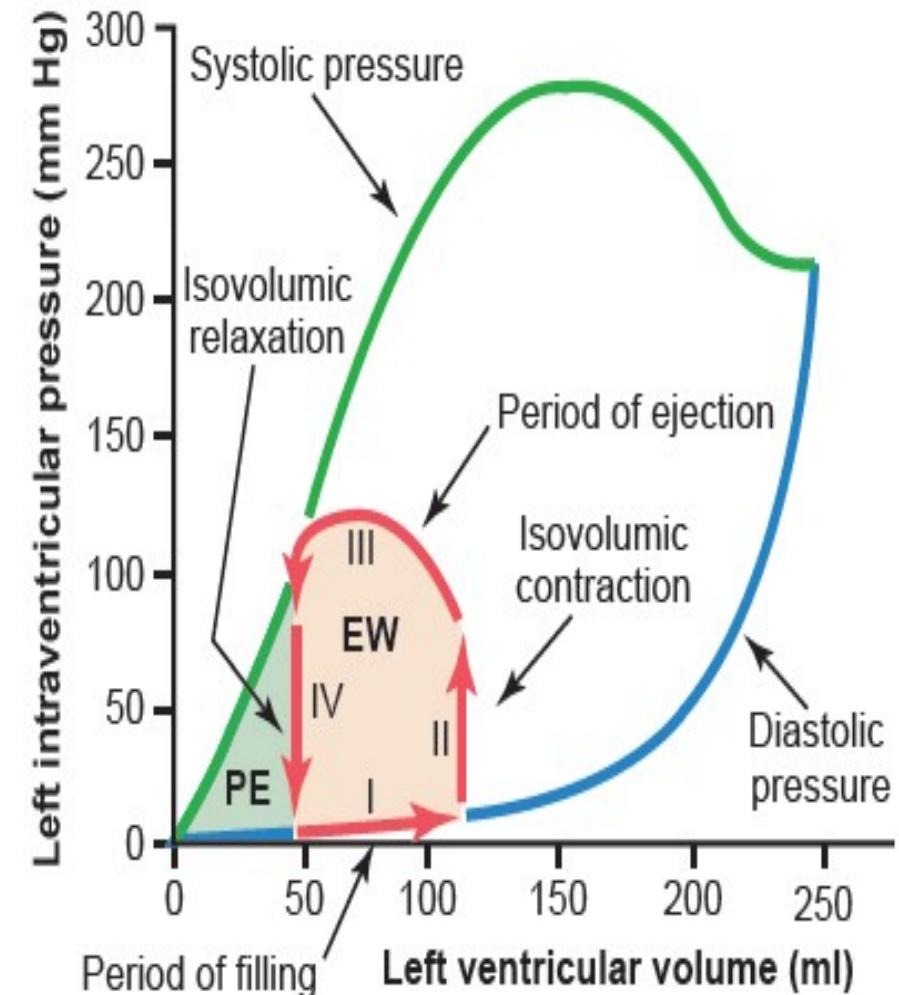
- **is work done by heart in whole minute.**
- **Minute work = stroke work × heart rate.**



Cardiac work



- ✓ **work output of heart is in form of**
 - **External work** : include pressure and volume work.
 - **Kinetic energy** to give velocity to the blood (normally small and neglected = 1%. But increased in case of aortic stenosis).





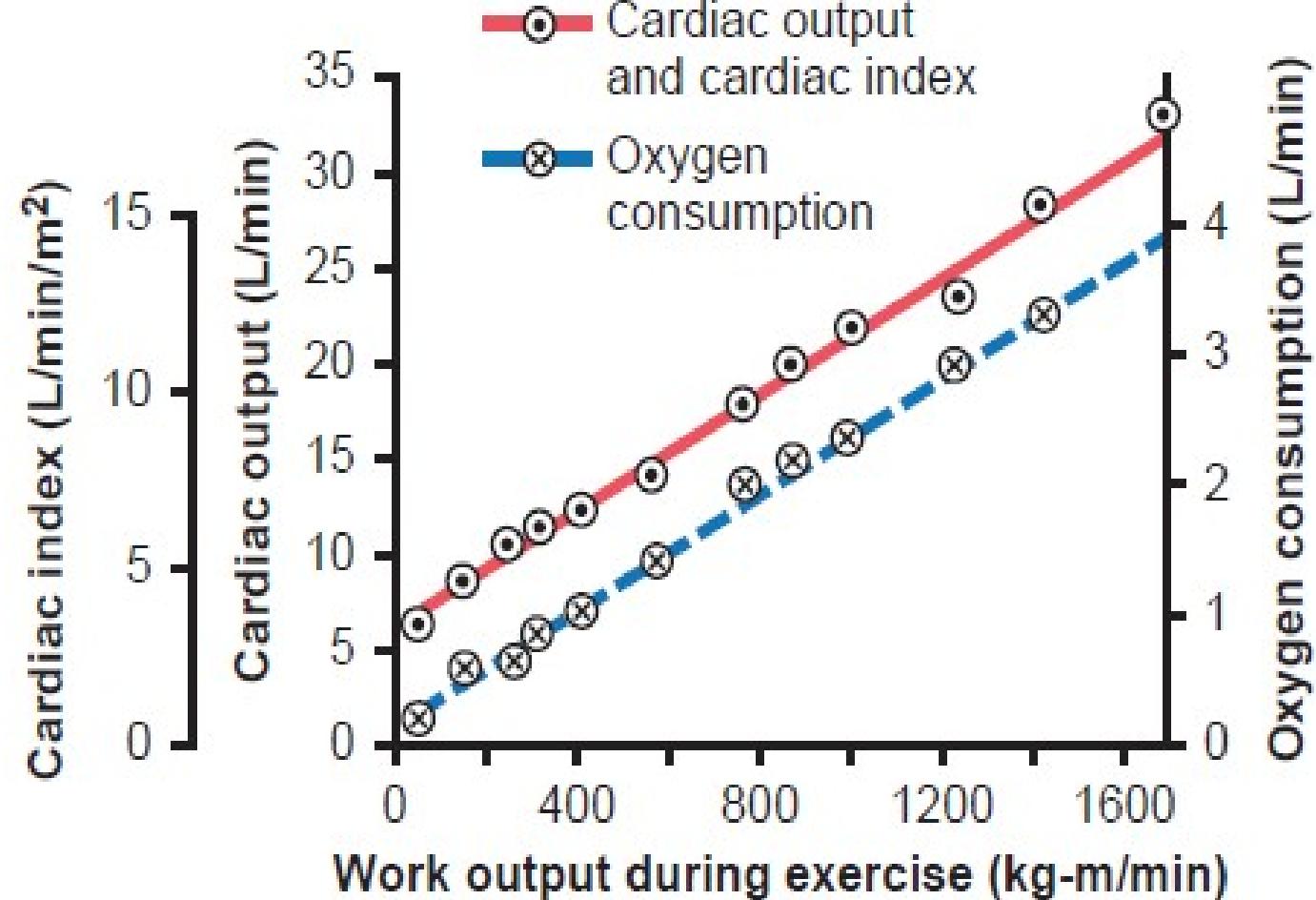
Mechanical efficiency of the heart :

- ✓ The efficiency of the heart may be calculated as the ratio of the work accomplished to the total energy used. Normally, it is 20-25%.
- ✓ It is decreased with increased after load, preload, heart rate and heart dilation.
- ✓ It is increased with hypertrophy.

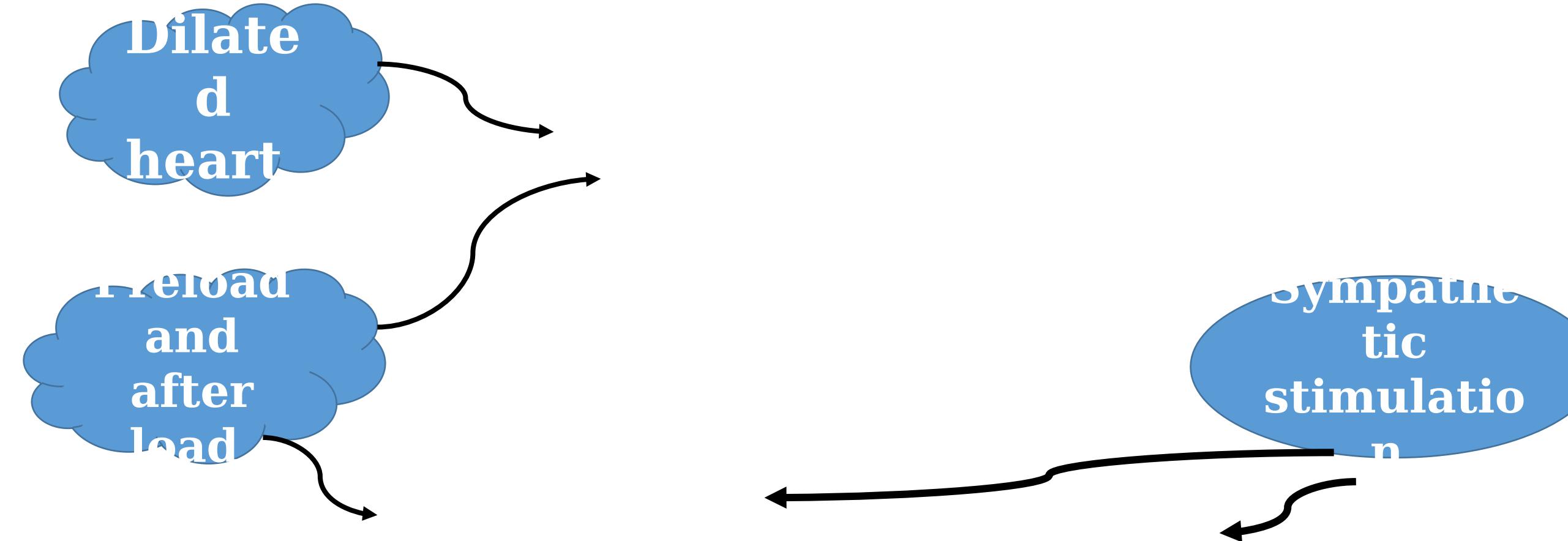


Cardiac O₂ consumption

- ✓ O₂ consumption by the beating heart is about 9 mL/100 g/min at rest.
- ✓ O₂ consumption increases in exercise.
- ✓ O₂ extraction by cardiac muscles is high so increases in O₂ consumption require increase in the blood flow



Cardiac O₂ consumption



Lecture Quiz



Question 1

What are types of cardiac work ?

Stroke work, minute work, volume work, pressure work.

Question 2

In athlete heart, work by the heart is increased by all the following except :

- a) Increased heart rate
- b) Increased myocardial contractility
- c) Increased intramyocardial tension
- d) Increased diameter of the ventricles

d

SUGGESTED TEXTBOOKS



1. Ganong 23rd edition P 678 to P. 685

2. Guyton and Hall 13th edition P. 118. to P. 120



Thank you



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